METHOD FOR MARKING A VEHICLE WHEEL FOR SUBSEQUENT IDENTIFICATION AND TRACKING

Technical Field and Background of the Invention

The present invention relates generally to the concept of marking, removing and remarking a manufactured part, such as a vehicle wheel. The invention provides a novel, distinct solution for tracking vehicle wheels through various manufacturing stages.

It is important that many products are traceable back to and through manufacturing. Thus, for example, if a safety critical defect is detected in a particular item, then products with the same history can be identified and tracked down to minimize damage and liability. As such, it is essential that many products be permanently marked in such a manner that manufacturing records for the product can be retrieved for analysis at an unknown future time. For example, aluminum wheels are a primary structural component of an automobile that requires full traceability for safety reasons.

The manufacturing of cast alloy wheels is generally an ordered process of sequential events. Some of these events are specific to an exact wheel model, while others are not. For example, machining is geometry specific. If the wrong casting is loaded in an automated machining cell, a dangerous and expensive crash occurs. Heat-treating, on the other hand, is non-specific to the wheel model. However, as heat-treating is approximately a single shift long process, it is still useful to know what is in the furnace for planning the subsequent operations. For reasons as diverse as these, it is advantageous to identify wheels during manufacture by their model number.

The most common method to identify wheels is by a human operator. But in

higher volume automated operations, this is both expensive and less than 100% reliable. Consequently, sensor-based wheel model recognition systems are desired. Various sensor technologies are used, the most prevalent being machine vision. Here, a snapshot of the wheel face is taken and compared against stored values. While this is generally straightforward for a human, it is a difficult task for machine vision, primarily because the snapshot is only a 2-D (two dimensional) image. Often such systems are only useful when other inputs are used in parallel, or series snapshots are required to eliminate the probability of misidentification.

Another method used to identify wheel models is a combination of basic wheel measurements and basic profiling of the wheel face—see U.S. Patent No. 6,173,213 to Amiguet et al. This method is used for the aforementioned critical machining operation. Wheel profiling is performed by laser distance measurement scans at several concentric diameters. This method is not inexpensive, it cannot differentiate wheels that share much common geometry, and it takes too much time for inline model identification without the massive parallelism that occurs in wheel machining.

Reliable marking and automated scanning into a manufacturing data base enables wheel serialization. A particular benefit is that scanning the serial number provides the exact wheel model and prior history, which is often necessary to adjust the upcoming process equipment. Currently, this is either done with operating staff or machine vision systems that look at the face of the wheel. For some processes, it is also important that the angular orientation of the wheel is also identified.

Machine vision determination of both wheel model and angular orientation is problematic. The method of the present invention addresses such problems by using the scanner to not only inspect the serial marking, but to also find an angular fiducial

mark on the wheel. In this regard, it may be advantageous to combine the simplified marking and scanning equipment with a separate sensor to locate the cast or formed-in angular fiducial mark. Thus, in one application, the present method marks the serialization numbering or coding in a protected area, such as the inboard flange outer surface region, and then uses a simple wheel handling system to pass this ring like area in front of a scanner for decoding, with or without also determining the angular orientation of the wheel.

Historically, products and components have been generally marked with numeric or alphanumeric coding. The basic techniques used for marking include engraving, stamping or embossing tags or labels, which are then attached to the product. Direct part marking (DPM) is often the lowest cost of marking products, as there are little to no marking expendables. While such marking is possible by various means, the most common method for imprinting metal parts is by impact, pressure or roll marking. All such marks are primarily intended for human visual interpretation, but they also can be read via machine vision using optical character recognition (OCR) software. OCR, however, is difficult and read rates are rarely ever in the 99+% range required for automated identification systems.

The need for automated rapid identification of general products has led to information encoded as 1-D bar codes for machine reading. These all-pervasive linear barcodes are typically high contrast marks, most often black bars on a white background to facilitate reliable and rapid scanning and decoding. When low contrast barcodes are used they generally are unreliable with conventional scanners. A solution used to overcome the low contrast issue is to use a particular type of 2-D barcode, where the bars are either below or above the general surface. Then, by using more

sophisticated scanners based on laser distant measurement units, these codes can reliably read. This type of 2-D barcode is called a "bumpy bar code" by some.

There is a second, more common form of 2-D barcodes used for marking product, although they are not cast or formed in. Unlike bumpy bar code, the code is marked in one flat plane, more or less as conventional linear barcodes are. This type of 2-D area barcode offers the ability to provide very dense information coding, as well as redundant information and error correction if the code is damaged. There are a number of such codes, with 2-D Data Matrix being one of the more common. One disadvantage of such codes is they require more sophisticated scanners, although this is not much of an issue for high contrast codes.

It is becoming more common that 2-D Data Matrix like codes are formed by DPM processes. While such laser formed marks are more or less 2-D, interestingly, peened marks are actually 3-D marks. Either way, low contrast is often encountered, and such marks can only be scanned satisfactorily when special contrast enhancing lighting and narrow field of views are practiced. Eliminating surface variations in the area carrying the mark and controlling its orientation relative to the scanner are often required to improve automated read rates.

Alloy wheels typically are hand stamped with production batch information for manual viewing by humans. These codes are most typically marked on stamp pads in protected areas such as the lightening pockets in the back of the spokes of the wheel center section. But these areas vary greatly from wheel model to wheel model, which makes this a chiefly impractical task for automated scanning.

There are a number of regions on the wheel surface that individually could be standardized as a marking area for simplified automated scanning. Unfortunately, a

very large percentage of the surface area of the original formed wheel shape is machined away and there are essentially no common secure regions for marking, unless the wheel design variations are restricted.

Multiple marking may be provided around the circumference of a round part to allow scanning without stopping and rotating in front of a scanner. This concept also comprises marking on the portion of the wheel that is not removed in the first turning operation, so that the remarking can be done before the initial casting mark is machined off. The rim profile can be used for wheel identification, as discussed below.

Basically, if a distance scan from the side of the full side is done as a wheel is conveyed by, it is easy to extract the wheel diameter and width. While this does not identify the exact wheel model it does narrow the possibilities considerably. Because the actual rim profile for a particular width wheel is not likely to be designed exactly the same, the model choices are narrowed even further. In the case where there are multiple molds of the same model, they can be distinguished from each other by casting-in or machining-in a ring like barcode. Thus, it is possible to identify a wheel model, size, and mold number on-the-fly with a laser distance profile scanner. Further, it is even possible to tell angular orientation with such a scan when a pattern of male or female notches are added to the rim sidewall or outboard lip protector.

Summary of Invention

Therefore, it is an object of the invention to provide a method for marking a vehicle wheel for subsequent identification and tracking.

It is another object of the invention to provide simplified marking and tracking capability for any wheel model, regardless of size or design. The key aspect is failsafe reading of a first applied code, followed by its subsequent removal and replacement in

a fail-safe manner.

A fundamental characteristic of the present invention relates to first operation machining, as an original ID mark (e.g., 2-D data matrix code) applied immediately after casting, and used to identify and track the wheel up to and into the machining cell, is machined off. However, since a raw casting is loaded into the first operation lathe and then unloaded about a minute later with the back portion in final form, this ID mark is immediately re-applied to a finish machined location on the wheel. The new ID mark ensures that not only the history file up to this point is available, but also any subsequent manufacturing and inspection history up until wheel shipment is added. The coded serial number provides permanent traceability for future analysis.

This transferred serial identification can be applied to several locations on the wheel and by several methods; it also can be applied while in the first operation lathe or immediately after removal by the robot. For example, since the backside of a wheel rim and center experience full weather they quickly become grimy. A simple ink code would be difficult to find in the future, and might be removed by cleaning. On the other hand, the tire side of the rim is a clean environment where an ink stamp is protected. A serial number can be percussively marked on either side of the rim, and so on. And while an actual alphanumeric serial number is most likely necessary, a 2-D bar code can also be added, and/or specific items such as completion date. In other words, a complete history file could be printed/engraved on the wheel, or only a serial number and required information. It is also possible to apply a less permanent code on exiting first operation turning, and later in the manufacturing process, for example at the very end, convert this second temporary mark to a permanent number and record.

It is another object of the invention to provide an automated wheel tracking

system which comprises a first wheel model and angular position identification stage, followed by a means to convey the wheel directly in front of a scanner with a field of view smaller than the wheel by either moving the scanner or wheel to intercept the mark as it is conveyed by, ideally without any change in conveying characteristics.

It is another object of the invention to machine-identify a vehicle wheel as it is conveyed through downstream manufacturing processes without stopping and rotating the wheel.

It is another object of the invention to scan vehicle wheels as they are conveyed past suitable scanners at typical speeds in excess of 1 foot per second.

It is another object of the invention to form an original serial ID mark on a vehicle wheel as it is being created, either by the casting or primary shape forming process.

These and other objects of the present invention are achieved in the preferred embodiments disclosed below by providing a method for marking a vehicle wheel for subsequent identification. The method includes the steps of forming a basic wheel shape, and marking the wheel shape with a first ID mark. The wheel shape is then machined in regions including that of the first ID mark to create a finished wheel. To "machine in regions including that of the first ID mark" means to engage or penetrate the surface of the wheel in a manner which removes all or a portion of the ID mark. After machining, the finished wheel is marked with a second ID mark.

According to one preferred embodiment of the invention, the first ID mark is located on a rim barrel of the wheel shape.

According to another preferred embodiment of the invention, the first ID mark is located on an inboard flange of the wheel shape.

Preferably, the second ID mark is located on an inboard flange of the finished

wheel.

According to one preferred embodiment of the invention, the first and second ID marks are located on respective opposite sides of the inboard flange.

According to another preferred embodiment of the invention, both of the first and second ID marks are located on a single side of the inboard flange.

Preferably, the second ID mark is located on an inside surface of the inboard flange.

According to another preferred embodiment of the invention, the second ID mark is applied to the finished wheel in substantially the same region as the first ID mark on the wheel shape.

According to another preferred embodiment of the invention, the method includes the step of removing the first ID mark during the machining step. The ID mark is "removed" when it is no longer operable for machine-readable identification.

Preferably, the first ID mark is a machine-readable code.

Preferably, the second ID mark is a machine-readable code.

In another embodiment, the method includes the steps of forming a basic wheel shape, and marking the wheel shape with an ID mark. The wheel shape is then machined in regions including that of the ID mark to create a finished wheel.

In yet another embodiment, the method includes casting a basic wheel shape comprising a wheel rim and hub. The wheel rim defines a rim barrel, inboard flange, and outboard flange. The inboard flange of the wheel rim is marked with a first ID mark. The wheel shape is then machined in regions including the inboard flange to create a finished wheel. The first ID mark is removed in the machining step above. An inboard flange of the finished wheel is then marked with a second ID mark.

Brief Description of the Drawings

Some of the objects of the invention have been set forth above. Other objects and advantages of the invention will appear as the description proceeds when taken in conjunction with the following drawings, in which:

Figure 1 is a fragmentary, perspective view of a vehicle wheel suitable for ID marking according to a process of the present invention;

Figure 2 is a top view of the vehicle wheel;

Figure 3 is a cross-sectional view taken substantially along line 3 of Figure 2;

Figure 4 is an enlarged fragmentary cross-section of the vehicle wheel in an area of the machine-readable ID mark;

Figure 5 is a surface view of the ID mark;

Figure 6 is an enlarged fragmentary view of the wheel showing the machined-off casting portion in phantom;

Figure 7 is an enlarged fragmentary view of the wheel after machining;

Figure 8 is an enlarged fragmentary view of the wheel showing the location of the first and second ID marks according to one preferred embodiment;

Figure 9 is an enlarged fragmentary view of the wheel showing the location of the first and second ID marks according to a second preferred embodiment;

Figure 10 is an enlarged fragmentary view of the wheel showing the location of the first and second ID marks according to a third preferred embodiment;

Figure 11 is an enlarged fragmentary view of the wheel showing the location of the first and second ID marks according to a fourth preferred embodiment;

Figure 12 is an enlarged fragmentary view of the wheel showing the location of the first and second ID marks according to a fifth preferred embodiment;

Figure 13 is an enlarged fragmentary view of the wheel after machining and showing the location of the second ID mark according to one preferred embodiment;

Figure 14 is an enlarged fragmentary view of the wheel after machining and showing the location of the second ID mark according to a second preferred embodiment and;

Figure 15 is an enlarged fragmentary view of the wheel after machining and showing the location of the second ID mark according to a third preferred embodiment.

Description of the Preferred Embodiment and Best Mode

Referring now specifically to the drawings, a vehicle wheel suitable for identification marking according to a method of the present invention is illustrated in cross-section in Figure 1, and shown generally at reference numeral 10. The vehicle wheel 10 is formed by first casting (or forging) a basic wheel shape. This basic wheel shape is later machined and finished in a conventional manner known and practiced in the industry.

As shown in Figures 1-3, the vehicle wheel 10 comprises an integrally-formed center hub 11 and wheel rim 12. The wheel rim 12 has an inboard flange 14, an opposing outboard flange 15, and a rim barrel 16 extending between the inboard and outboard flanges. Respective tire bead seats 18 and 19 are formed adjacent the rim flanges 14, 15 for locating the beads of a standard pneumatic tire. The present method includes marking these various regions of the wheel 10 with machine-readable data sufficient to identify the wheel 10 both during and after manufacture. The data is preferably contained in 1-D or 2-D barcodes which are laser-formed or peened using a DPM process. Figures 4 and 5 illustrate one example of machine-readable code "C" which may be applied to the vehicle wheel 10. Other examples of machine-readable

code are disclosed in the guide entitled "Understanding 2D Symbologies" published by AIM of Pittsburgh, Pennsylvania. The complete disclosure of this publication is incorporated herein by this reference. The Mark 'n Read™ system by Technifor Inc. of Charlotte, North Carolina offers another example of direct part marking.

For tracking purposes and identification, the vehicle wheel 10 is marked with an initial ID mark after casting and before machining, and then with a final ID mark after machining. The ID marks provide useful information regarding the vehicle wheel, particularly as it moves downstream through various stages of manufacture. This information may include, for example, the serial number, wheel model, size, mold number, angular orientation, etc. A conventional scanner or other appropriate reader is operatively positioned to read and record the ID marks on-the-fly as the wheel 10 is conveyed between processing stations.

Standard line of sight tracking systems require the wheel ID marks to be presented to the scanner's field of view. While several technologies are suitable, to get high resolution the distance from the ID mark to the scanner must be kept within a relatively tight range—usually under 50mm. The field of view of high-resolution scanners is also relatively limited—in the 100mm range. The ID mark, which can be any size but is typically in the 10mm range, is preferably perpendicular to and in the same plane as the scanner.

Once cast, the basic wheel shape goes through a serial array of subsequent processes, each creating various obstacles for mark retention and reading. Not all wheels 10 go through all processes, but the menu, somewhat in order of typical use, includes: deflashing (fettling), desprueing, fluoroscopic inspection, solution heat-treatment, quenching, aging heat-treatment, shot blasting, painting, machining, clear

coating and final inspection. Solution heat-treating occurs at a temperature close to the melting point of aluminum, shot blasting modifies the surface and abrades it, while painting and clear coating pass the wheel through aggressive cleaning and surface chemistry modifications.

Preferred Marking Technique

The fundamental technique of the present invention is to apply the initial ID mark to the cast wheel shape in an area that facilitates human to fully automated reading, and to maintain this ID mark for wheel identification throughout downstream processing. When the wheel casting is machined, the initial ID mark is removed and the final ID mark permanently applied without losing the wheel identification.

Based on relative machining allowances in current OEM wheels, the inboard rim flange 14 and rim barrel 16 are preferred locations for depth contrast forming or cutting of the first and second ID marks. Figures 6 and 7 illustrate this region of the wheel 10 at casting (shown in phantom) and then after machining, respectively. In Figure 8, the initial ID mark "A" is applied to an inside of the rim barrel 16 at casting. After machining, this mark "A" is removed and the final ID mark "B" applied to an outside of the inboard flange 14. In Figure 9, the initial ID mark "A" is applied to the outside of the inboard flange 14 at casting. After machining, this mark "A" is removed and the final ID mark "B" applied in substantially the same location. In Figure 10, the initial ID mark "A" is applied to one or both of the inside of the inboard flange 14 and an outside of the rim barrel 16 at casting, and the final ID mark "B" applied to the outside of the inboard flange 14. In Figure 11, the initial ID mark "A" is applied to the outside of the rim barrel 16 at casting, and the final ID mark "B" applied to the inside of the rim barrel 16. In Figure 12, the initial ID mark "A" is applied to the inside of the rim barrel 16 at casting,

and the final ID mark "B" applied to the outside of the rim barrel 16.

In any marking region, the casting or forging machining allowance may, or may not be fully used, and the initial ID mark in turn may or may not be fully removed. In the present method, any remnant or "shadow" of the initial ID mark would be a nuisance for remarking and reading. There are two preferred solutions to this problem, as described below.

Almost all machining is done in fully automated cells where wheels are transferred in succession from machine to machine. After confirming that the correct wheel is entering the cell (thus avoiding expensive crashes), an automated system determines the precise angular orientation of the wheel for purposes of drilling the lug and valve holes. The initial mark is then removed during machining, as previously described. Before the wheel leaves the machining cell positioning control, the removed initial ID mark is immediately replaced with the final ID mark by application of a similar DPM process, thereby maintaining continuity in the specific wheel identity. By locating the initial ID mark in the same angular position for the same wheel model, the cell position control can dictate location of the final ID mark in an adjacent planar position, such as the preferred flange exterior, where there is no interference with any possible remnant of the initial ID mark. In theory, it is even possible to mark exactly over the initial ID mark (See Figure 9).

The second solution to the potential nuisance shadow created by the initial ID mark involves the two sides of the inboard flange which are suited for subsurface marking. By marking the original cast or forged shape on one side, and then remarking on the opposite side after machining, there can be no mark scanning conflicts as the before and after machining scanners would focus on opposite regions. As mentioned

above, a preferred location for the initial ID mark is the outside inboard flange surface, based on the possibility of a deflash. This leaves the rim exterior including an inside of the inboard for the final ID mark. As indicated in Figure 13, the tire "T" sits and seals primarily on the axial bead seats 18, 19 of the rim 12, and is forced against the flanges 14, 15 by pneumatic pressure. Thus, the final ID mark "B" on the inboard flange 14 is not viewable once the tire "T" is mounted. However, prior to mounting, the ID mark "B" could be readily scanned in the wheel production plant and into the tire mounting machinery in the OEM assembly plant. The tire "T" would also protect the mark "B" throughout the wheel life. As shown in Figure 14, it is also practical to reverse this single flange marking order so that the final ID mark "B" would be available for line of sight scanning on the outside of the inboard flange 14.

The final wheel ID mark "B" provided on the inside of the inboard flange 14, as shown in Figure 13, is possible because the tire "T" seats and seals on the 5 degree tapered bead seat 18 and not the flange 14. This suggests that a through-hole 25 (Figure 15) formed with the flange 14 is also possible for the ultimate deep depth contrast mark "B". Since one of the main reasons for deep depth contrast is to provide easier to scan marks, this through-hole approach allows lighting on one side for simplified high visual contrast scanning on the opposite side. In addition, the through-hole 25 may be formed at casting as an initial ID mark and then survive the machining process for final ID marking.

Alternative Marking Regions

Alternative regions exist on the wheel for ID marking according to the present identification and tracking method. The hub surface has the attraction of being well protected by the rim and fully parallel with the rim flange of conveyance. However, as

the width and offset changes from wheel model to wheel model, the distance from a scanner located below the conveyor level is both significantly large and variable. To achieve the high resolution required, machine vision systems can only provide a measurement range of around 25mm, which is far less than the backside setting (akin to offset) variation. Hence, a sensor to detect the distance to the hub and a focusing mechanism is required.

The lightener pockets of the spokes are an attractive positions for marking, but they also suffer from the just described refocusing necessity. More significantly, lightener pockets are not always available and are not generally located in a common position from wheel model to wheel model.

The rim barrel is an attractive area for the initial wheel shape ID marking. Marking the interior is attractive as it is naturally protected, but this does limit the size of the marking tooling as it must fit inside the rim circumference to mark the rim wall square on. Similarly, while it is possible to scan the coded surface at a considerably oblique angle, the desired square-on scanning dictates that the scanner be raised up into the rim for scanning and then withdrawn to allow continued conveying.

The rim exterior is in many ways an ideal location for marking. For example, the scanner can be located to the side of the conveyor where there are less cleanliness issues than under it. While this area is not as well protected from handling damage as the interior portions, the flange does afford some protection to the rim barrel region. Unfortunately, it is not uncommon for wheel manufacturers to take a crude cut to remove flash formed at the junction of the side cores, as well as the junction with the main top and bottom cores. In some cases the practice includes removing significant cast stock from the rim exterior before the wheel continues to the required downstream

processes. Thus, any ID mark on the rim exterior is likely to be damaged, if not removed. This would necessitate an additional mark and remark operation beyond that usually required at machining.

A method for vehicle wheel marking and identification is described above. Various details of the invention may be changed without departing from its scope. Furthermore, the foregoing description of the preferred embodiment of the invention and best mode for practicing the invention are provided for the purpose of illustration only and not for the purpose of limitation—the invention being defined by the claims.